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WRITTEN LISTS AS MEDIATING STIMULI IN THE MATCHING-TO-SAMPLE PERFORMANCES OF INDIVIDUALS WITH MENTAL RETARDATION

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Students with mental retardation learned to write lists in order to perform a matching task that they could not do otherwise. After an initial assessment phase, reinforcement was arranged in the computerized tasks to follow selection of the six pictures that were identical to those in the six-picture samples presented. In Study 1, even though the participants wrote a list of the names of the six sample pictures on each trial, read a list, or did both, they often made errors when a brief delay preceded picture selection. In contrast, performance was nearly perfect when a list was written, read, and remained available at the time of picture selection, suggesting that the list served to mediate the delays. Study 2 examined the stimulus control by two- and six-picture samples over the list writing. Early during testing, 1 participant refrained from writing lists on two-picture trials but wrote lists on six-picture trials, thereby maximizing reinforcement and minimizing its delay; the other participant showed this pattern of list writing after supplemental training. The studies suggest methods for establishing a rudimentary repertoire of mediating behavior that has relevance for teaching instruction-following skills in natural settings.

DESCRIPTORS: spelling, writing lists, matching to sample, stimulus control, mediation

Individuals who write lists of instructions, such as the names of things to be gathered in a grocery store, may be more apt to follow instructions when they write the lists than when they do not. The likelihood of gathering the listed items increases because, like oral naming (Constantine & Sidman, 1975; Geren, Stromer, & Mackay, 1997; Gutowski, Geren, Stromer, & Mackay, 1995) and other forms of verbal behavior (e.g., Guevremont, Osnes, & Stokes, 1988), writing the list may serve important functions in facilitating or even enabling later behavior. First, the list writing may ensure that the relevant instructional stimuli have been observed and thus may facilitate the occurrence of later behavior, just as would naming or other differential behavior. In addition, writing the list may be precurrent behavior (see Skinner, 1968) that produces stimuli that occasion later behavior even more effectively than naming each item orally, or even repeating the list, in a typical form of rehearsal. The written list provides the relatively permanent stimuli that can (but need not) exercise discriminative control over responding at the time and place where the things to be gathered are located (e.g., Stromer, Mackay, Howell, McVay, & Flusser, 1996). More broadly, as Skinner (1983) suggested, memoranda may usefully replace memories (and see Epstein & Skinner, 1981). Written lists have the general advantage that they may be used to occasion appropriate behavior in in-

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struction-following tasks that are considerably more complex than might be possible without a list. To provide a firm basis for teaching the critical components of the adaptive skills that are involved, the present investigation examined the possible mediating function of list writing apart from its observing function.

This research is an extension of earlier work in which matching-to-sample tasks were used to help to distinguish the potential mediating functions from the observing functions of oral naming (e.g., Constantine & Sidman, 1975; Geren et al., 1997; Gutowski et al., 1995). This extension may be illustrated by considering that one's use of a written list in a grocery store requires simultaneous matching: The list may be viewed as a multielement sample or instructional stimulus, and the items to be gathered are the comparison or discriminative stimuli. Moreover, the written list may acquire its instructional functions, not via direct training, but because the items listed substitute for the stimuli that gave rise to the list. Thus, a list that is written in response to a set of instructional stimuli (e.g., objects, pictures, or dictated words) may itself function as an instructional stimulus (e.g., Mackay, 1985; Mackay & Sidman, 1984; Stromer & Mackay, 1992, 1993) that mediates additional behavior that remains relevant to the original stimuli. For example, Stromer, Mackay, Howell, McVay, and Flusser (1996) used computerized methods to establish a participant's written spelling in the context of the following retrieval task: First, two objects were displayed on a table and their names were written on a list. Then, with the list in hand, the participant selected the objects from among others on a shelf in another room and placed them on the table to end the trial. In a subsequent assessment, the nearly perfect retrieval of objects that occurred on trials with a list declined on trials conducted without a list, suggesting that the list may have served to mediate delays in retrieval by exerting discriminative control of object selection at the shelf.

In the present study, the assessment of the effects of mediation used up to six rather than only two stimuli (as used by Stromer, Mackay, Howell, McVay, & Flusser, 1996). We also examined whether the number of stimuli to be selected might come to exert discriminative control over writing and using a list. As a practical example, someone who goes shopping for only two items may not use a list because success occurs reliably without one and, besides, writing a list takes extra time and effort. In contrast, if six or more items are sought, only writing a list and using it at the store may ensure success. We explored the mediating effects of lists written by 3 participants with mental retardation, one of whom had more impoverished communication and academic repertoires than our earlier participant (Stromer, Mackay, Howell, McVay, & Flusser, 1996). Computerized tasks were used in which each sample stimulus was, nominally, a group of two, four, or six pictures (from a pool of 12 pictures), and selection of the identical two, four, or six comparison pictures was reinforced. These tasks were used because of the precision with which stimulus and response events could be arranged and analyzed, and because of the relevance of such laboratory methods for teaching (as discussed by Mace, 1994; Wacker, 1996).

A preliminary phase assessed delayed picture matching on trials in which the participants wrote a list of the names of two, four, or six sample pictures, read the list, and then, with the list concealed, selected comparison pictures. Next, Study 1 examined whether six-picture matching was more accurate on trials in which a written list was available at the time the participant selected the comparison pictures than on trials in which a list was written, read, or both, but then was not available during comparison se-

lection. Study 2 examined the preferences of 2 of the participants for not writing versus writing and keeping a list on trials with two- and six-picture samples.

GENERAL METHOD

Participants

Three individuals with mental retardation participated. Cory was 19 years 2 months old, Ben was 16 years 4 months old, and Lori was 11 years 11 months old. Their mental age-equivalent scores on the Peabody Picture Vocabulary Test were 7-11 (Cory), 7-2 (Ben), and 3-11 (Lori); their grade-equivalent scores in reading and spelling on the Wide Range Achievement Test were below Grade 3. All participants were proficient on several tasks involving the stimuli used in Studies 1 and 2. They used the computer to spell each word to its picture and to dictation (e.g., Stromer, Mackay, Howell, McVay, & Flusser, 1996), wrote the picture names to the pictures and to dictation, named the pictures and their corresponding printed words orally, and matched pictures and printed words.

Apparatus

A Macintosh® computer with a touch-sensitive screen presented stimuli and recorded data. The locations of sample and comparison pictures were also response keys. As sample stimuli, one, two, four, or six pictures appeared in the upper part of the computer display. The 10 comparison pictures were presented at the bottom. After a comparison picture was touched, it appeared in the construction area below the area where the sample stimulus had been presented. Touching the START OVER key restarted a trial by erasing pictures already in the construction area and restoring the display of comparison pictures. Touching the DONE key ended a trial. Tape recordings were made when the procedure required oral naming.

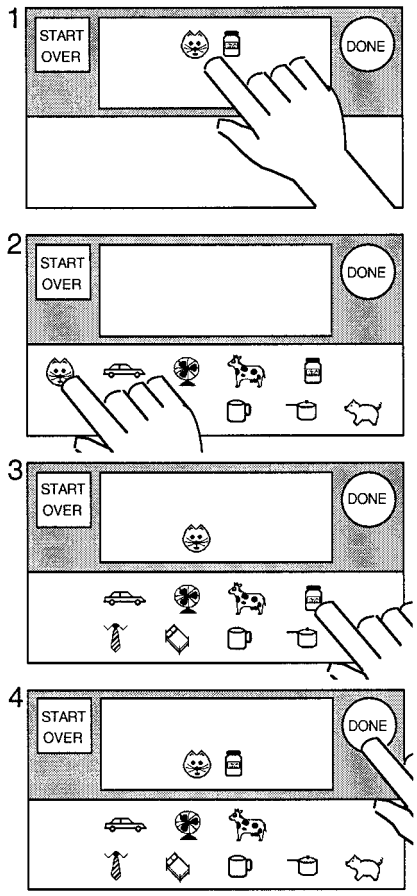

Figure 1. Schematic of a correct delayed matching trial: Touching the two-picture sample removes it and produces 10 comparison pictures (Panels 1 and 2). Each touch to a comparison that matches a sample picture moves that picture to the construction area (Panels 2, 3, and 4). Touching the DONE key ends the trial (Panel 4) and touching the START OVER key begins the trial again.

General Procedure

Sessions lasted 10 to 15 min and were conducted 3 or 4 days per week. A trainer, who was seated behind and to the right of the participant, monitored each session, delivered pennies, and conducted the naming and writing parts of some trials.

Matching to sample. Figure 1 illustrates a delayed matching trial involving a two-picture sample. The task was to touch (regardless of order) only those pictures in the choice pool that were identical to those in

the preceding sample before touching the DONE key. Ten of the 12 available pictures (bed, bus, car, cat, cow, cup, dog, fan, jar, pig, pot, and tie) appeared in the choice pool on all trials, the two (on other trials one, four, or six) that matched the sample and the remainder selected randomly by the computer. The particular sample and the positions of the comparisons changed unsystematically from trial to trial. A trial was coded correct by the computer (e.g., Figure 1) only if the pictures that were selected from the choice pool were identical to those presented in the sample. An incorrect trial was coded if the DONE button was touched (a) before all of the comparison pictures that were in the sample had been selected (e.g., if only zero to five selections had occurred on a trial with a six-picture sample) or (b) after the selection of one or more pictures that had not appeared in the sample. A correct trial produced a flashing computer display, a penny, and a 3-s intertrial interval. An incorrect trial darkened the screen for 1.5 s; the intertrial interval then began. The START OVER key was effective until the DONE key was touched to end the trial.

Written naming to pictures and reading. On some trials, the participant had to write the name of each sample picture on a list before responding to the comparison stimuli. On some of those trials, the participant also read aloud each of the words just written. On other trials, a prepared list was given to the participant. When the required written and oral responses were correct, the trial continued and the consequences described above were in effect for correct and incorrect selections of comparisons; when an error in either the written or oral response occurred, the response was corrected with a modeling prompt (the trainer said the name or showed an index card with the name written on it), which the participant imitated, before the trial continued.

Reliability

An independent observer assessed the trial-by-trial reliability of (a) the trainer's scoring of a participant's handwriting and oral naming and other behaviors (choice responding and oral self-instructions in Study 2) that were not automatically recorded by the computer, and (b) the trainer's provision of materials for trials, correction of errors, and end-of-trial consequences. These assessments took place in 44% of the sessions and included at least one assessment in every condition of preliminary training and testing, Study 1, and Study 2. Across assessments, interobserver agreement was always 100% for the trainer's scoring of the participants' handwriting and other behaviors; agreement scores for oral naming ranged from 83% to 100% (M = 96%). Agreement scores for the trainer's task presentation ranged from 88% to 100% across assessments (M = 99%).

PRELIMINARY TRAINING AND TESTING

This phase assessed delayed matching with two-, four-, and six-picture samples. In addition, the participants were required to write a list of the names of the pictures in each sample and read the list before attempting a delayed match. The purpose was to familiarize the participants with the tasks to be used in later studies, and, specifically, to identify sample stimuli that they could and could not match reliably.

One expectation was that the trials with two-picture samples would yield few if any errors. This outcome was expected because the writing (and then reading) of the samples constitutes differential responding of a kind that may yield accurate performance on delayed matching tasks with two-picture samples (Gutowski et al., 1995; cf. Stromer, McIlvane, Dube, & Mackay, 1993). However, errors were expected on trials with four-

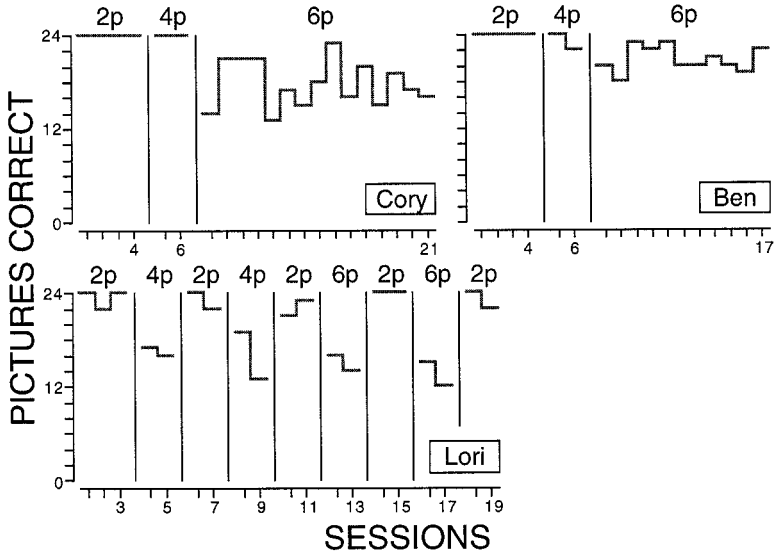

Figure 2. Results of preliminary training and testing: number of correct picture selections per session (24 possible). Vertical lines separate sessions involving samples with two (2p), four (4p), and six (6p) pictures.

picture or six-picture samples, or both, because previous research has shown that individuals with mental retardation may have difficulty on such tasks involving four sample elements, even when differential responding is involved (e.g., Dube, Kledaras, Iennaco, Stoddard, & McIlvane, 1990).

Procedure and Results

Cory, Ben, and Lori were exposed to preliminary sessions that began and ended with 12 trials that involved delayed (0 s) matching of single pictures. These trials began with presentation of a sample stimulus. The participant's response to the sample removed it from the computer screen and immediately produced the comparison stimuli. In the middle of each session, a block of write/read trials consisted of either 12 trials with two-picture samples, six trials with four-picture samples, or four trials with six-picture samples. On these trials, the participant was given a slip of paper and was asked to write a list of the sample picture names. After the list was written correctly (errors corrected as above), the trainer placed a cardboard shield in front of the computer screen and the participant read the list aloud. After the list was read correctly (errors corrected as above), it was handed to the trainer who concealed it. Next, the trainer reached behind the shield and touched the sample to remove it from the screen and produce the comparisons. Then removal of the shield allowed the participant to make selections among the comparison pictures.

Cory and Ben were given four sessions with two-picture samples and two sessions with four-picture samples before receiving 15 (Cory) and 11 (Ben) sessions with six-picture samples. Lori first received three sessions of trials with two-picture samples and then two sessions with four-picture samples. Two-session blocks with two- and then four-picture samples followed. Finally, successive two-session blocks used trials with two-, then six-, two-, six-, and two-picture samples. Figure 2 shows the number of correct pictures selected (out of 24) in each session. For Cory, the mean delayed matching accuracy for sessions with the two-, four-, and six-picture samples was 100%, 100%, and 74%, respectively; for Ben, accuracy was 100%, 96%, and 86%; and for Lori, accu-

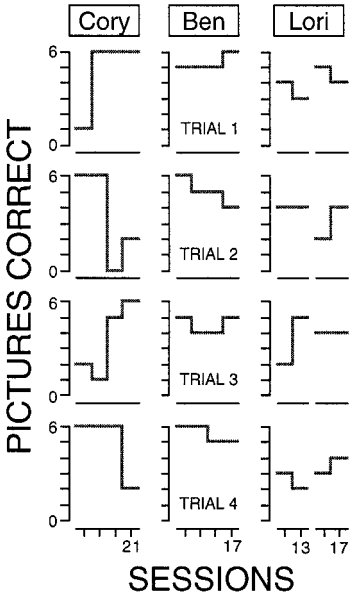

Figure 3. Results of preliminary training and testing: number of correct picture selections (six possible) on the four six-picture sample trials that occurred in each of four sessions for Cory (Sessions 18 to 21), Ben (Sessions 14 to 17), and Lori (Sessions 12 and 13 and 16 and 17).

racy was 96%, 68%, and 59%. Delayed matching of single pictures was nearly perfect throughout this assessment, as were the reading and spelling performances (in Studies 1 and 2 also).

Figure 3 shows a more detailed analysis of performance on the four trials with six-picture samples that were presented in the four sessions given to Lori and the last four sessions given to Cory and Ben. The participants' performances on these trials with six-picture samples is a focus because Studies 1 and 2 used that task, and the analysis shows the differences among individuals. Cory's correct selections ranged from zero to six (M = 4.2 correct); for Ben, the range was four to five (M = 5.1), and for Lori, the range was two to five (M = 3.6).

Discussion

As anticipated, all participants were highly accurate on the trials with two-picture samples and consistently made errors on trials with six-picture samples. Cory and Ben, unlike Lori, were accurate on trials with four-picture samples. Further research will be needed to determine whether the participants would have shown such accuracy had they not been required to respond differentially to the sample pictures on the write/read trials (cf. Gutowski et al., 1995). Also, further research will be needed to clarify the critical aspects of stimulus control that may have been established by the write/read requirements. The possible controlling stimuli include the pictures that were viewed as the lists of words were written, the printed words themselves, and the oral names produced when the list was read. Indeed, nothing about the procedure prevented the continuation of oral naming (of the words or the pictures) potentially mediating comparison selection. Although none of the participants showed any overt signs of such rehearsal, the possibility of mediation via covert oral naming cannot be ruled out. Whatever their basis for performing the task, the participants made errors on trials with six-picture samples consistently, and our objective in Study 1 was to demonstrate the superiority of having a written list available on such trials.

STUDY 1

Study 1 examined matching on four kinds of trials that involved different forms of responding to six-picture sample stimuli. On one kind of trial, a list was written, read, and kept available until the comparison pictures were selected and the DONE key was touched. In contrast, the list was never available at the time of matching on the other three types of trials in which a list of picture names was written and read, only written, or only read. We expected the accuracy on trials in which a list was available to surpass that on trials without a list. This was because tri-

als with a list permitted simultaneous matching of the pictures to the printed words on the list (like using a shopping list). In contrast, trials without a list seemed to involve delayed matching of the pictures to the sample stimuli presented at the trial onset, and, as shown in the preceding phase, errors may occur.

An ancillary interest was whether matching would differ among the three types of trials without a list. For example, one might expect accuracy to be highest on the trials that were preceded by writing and reading, intermediate on writing trials, and lowest on reading trials. This expectation is consistent with the observation that longer sample durations are associated with higher matching accuracy (e.g., Spetch & Treit, 1986). In the present study, the sample durations were longer on trials that involved writing and reading a list than on trials in which just writing the list was required. On the other hand, reading aloud may result in better matching than just writing. The explicit requirement to orally name the sample improves matching accuracy (e.g., Constantine & Sidman, 1975; Geren et al., 1997; Gutowski et al., 1995).

Overview

The 3 participants were given sessions (without verbal instructions) involving (a) an initial block of 12 delayed (0 s) matching trials with one-picture samples, (b) a block of four critical test trials (see below for delay durations), and (c) a final block of 12 one-picture delayed (0 s) matching trials. Performance on the four critical test trials was evaluated in each session, and the order of presentation of these trials changed unsystematically from session to session (a type of multiple treatment design; Kazdin, 1982, pp. 172–199). The samples for these trials were always six stimuli, but they differed because of the responses required to begin a trial: (a) Write/read/list trials involved writing a list, reading it, and then, after a delay, matching with the list on the table beside the computer; (b) write/read trials were as described for preliminary training and testing (writing, reading, delayed matching); (c) write trials involved writing a list, then delayed matching; and (d) read trials involved reading a list supplied by the trainer (no sample pictures were presented), then delayed matching. This study highlights the participants' performances on the critical test block (delayed matching with the one-picture samples was always nearly perfect).

Cory's Procedure and Results

Cory was given the four kinds of six-picture test trials with delay values of 0 s (Sessions 22 to 33), 5 s (Sessions 34 to 45), 10 s (Sessions 46 to 57), and 0 s (Sessions 58 to 64). The panels shown at the top left of Figure 4 reflect the number of pictures selected correctly (out of six possible) on each of the four critical trials presented in each session. Only the last six sessions for each trial type at each delay value are plotted (which are representative of all sessions at the delay value). Cory's scores were usually perfect on the write/read/list trials but were highly variable on the trials without a list (zero to six pictures matched). Differing from this pattern were Cory's near perfect scores on the write/read trials (second row) during the first and second exposures to the 0-s delay. These scores with a 0-s delay are better than those obtained during the preliminary training and testing, suggesting that practice with the matching task may have improved performance.

Ben's Procedure and Results

The panels at the top right of Figure 4 show Ben's data for the last six representative sessions for each trial type at each delay value. The delays were 0 s (Sessions 18 to 29), 5 s (Sessions 30 to 41), and 10 s (Sessions 42 to 53). During these sessions, Ben's

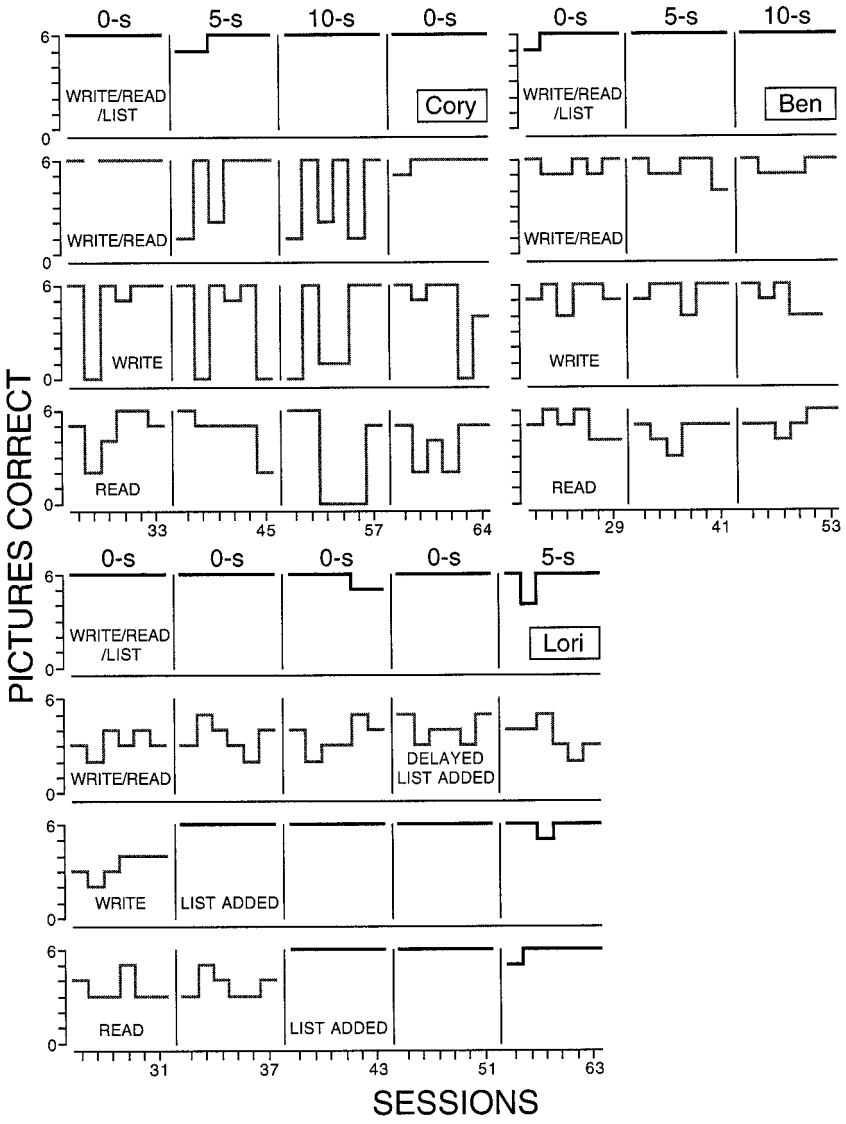

Figure 4. Results for Study 1: number of correct picture selections per session (six possible) on each of four kinds of six-picture sample trials. Vertical lines separate data for the last six sessions with a particular delay (top) or kind of trial (within panels). (The score in Session 29 for the write/read trial is missing because it was mistakenly conducted with the list available during picture selection.) For Lori, the list condition was added to the write trials in Session 32 and to the read trials in Session 38.

matching was usually perfect on the write/read/list trials but varied between four and six correct matches on the other kinds of trials.

Lori's Procedure and Results

The panels at the bottom of Figure 4 show Lori's data for the last six representative sessions, or all six of the sessions given, for each trial type at each delay value. The availability of the lists was manipulated across sessions in a modified multiple baseline design. Initially, Lori received the four trials with a 0-s delay (Sessions 20 to 31). During these sessions, Lori was perfect on the write/read/list trials and made from two to five

correct matches on the other kinds of trials. Next, Lori was allowed to keep the list she had written on the write trials (Sessions 32 to 37); then, Lori was also allowed to keep the prepared list used on the read trials (Sessions 38 to 43). Each time a written list was added, accuracy improved markedly. In contrast, errors continued to occur on the write/read trials.

The procedure for the write/read trials was then changed, first while using a 0-s delay (Sessions 44 to 51) and then a 5-s delay (Sessions 52 to 63). The new procedure examined whether Lori could rewrite lists of six picture names after the pictures had been removed from the computer screen but before picture matching was attempted. These delayed list trials began as before: The six sample pictures appeared and Lori wrote the names and read them. Lori was then told (only on the first such trial) to "look at the pictures carefully; now I'd like you to write your list after the pictures go away." Lori then kept the second list while she selected the comparison pictures. Figure 4 shows that Lori's scores on the delayed list trials were always imperfect.

Discussion

Matching with six-picture samples was more accurate on trials in which a list of the picture names was written, read, and kept available at the time of comparison selection than on trials without the list. This outcome occurred whether the delayed matching was preceded by writing and reading, only writing, or only reading. These results suggest that the lists actually were used and functioned as instructional stimuli that controlled selections of the picture comparisons. Moreover, periodic observations suggested that each participant often looked at the available list during the picture-selection part of a trial. They apparently did not ignore the list that was available and do delayed matching to the six-picture samples (or to some other aspect of the complex instructional stimuli), but instead matched the pictures to the printed words on the list. Except for Cory's accurate performance on write/read trials with 0-s delays, the participants' accuracy varied across the three kinds of trials without a list, with little difference among these conditions. These data thus do not explain the possible influence of sample duration or the different responses that were required to the sample stimuli.

The ease with which the participants came to use their written lists as aids to accomplish the required matching tasks was somewhat surprising and may mask the complexities involved in the task. The data suggest that the participants discriminated the differing demands required in performing the tasks with lists and without them. Without the lists, the task involved remembering which six of the 12 pictures had been presented as the sample or their printed and spoken names. Even when they engaged in the differential behavior of writing and naming the stimuli to be remembered, the participants had difficulty in accomplishing this kind of "memory span" task with high accuracy. In contrast, when a list was available throughout the trial, it was not necessary to remember which pictures to touch, only that comparison pictures were to be selected conditionally upon the contents of the written list that was available. The relations between the pictures and their names were well learned and did not change from one trial to the next. It was important to use the list, however, and the order in which the delays were presented may have helped to teach the participants to remember this. Initially, the list was written and remained in front of the computer as the picture comparisons appeared (0-s delay). Later the delays increased to 5 s and then 10 s. Other individuals might require more gradual and refined methods of explicit programming to achieve such outcomes.

Lori's data are additionally informative and strengthen the conclusion that the written lists served as mediating stimuli that bridged delays and then occasioned appropriate behavior. First, matching accuracy improved immediately when the list was made available at the time of matching, first on write trials and then on read trials. Not only did Lori match pictures to lists that she wrote, improvement on the read trials suggests that she also matched pictures to a list written by someone else. Second, to examine whether Lori could recall the lists she had written and read, we designed the delayed list trials, in which she had to write the same six-item list again, without the pictures on the computer screen. On these delayed list trials, Lori never succeeded in rewriting the six picture names, and, because this second list was the one available during comparison selection, matching accuracy remained low. If Lori's repertoire included some other mediating mnemonic behavior that might have improved matching performance, she did not display it during this study.

Lori's results also address the possibility that the contrast between the procedures on trials with and without a list may have had unintended, adverse effects on performance on trials without a list. One could argue that the removal of a list on these trials may have inappropriately signaled to the participant that the list contained errors. If so, this may have occasioned the selection of pictures that did not appear on the list, thus producing errors. This argument implies that the participants were capable of remembering the original list. However, Lori's performance on the delayed list trials argues against this possibility because she was unable to rewrite her lists accurately. In addition, we note that (a) all of the participants succeeded on trials with two-picture samples in which a list was written and removed (Cory and Ben also did so on trials with four-picture samples; see Figure 2), and (b) none of the participants appeared to show a degradation in performance on trials without the list: Cory's performance on the write/read trials with a 0-s delay actually seemed to improve when compared to his results during preliminary training and testing (see Figure 3), whereas Ben's and Lori's performances on these trials stayed about the same.

STUDY 2

Study 2 examined whether Ben and Lori could discriminate the circumstances in which writing a list was and was not beneficial in meeting the contingencies of reinforcement. An individual who has matched some samples without writing a list might forego the opportunity to write a list on similar occasions because the time taken to do so would delay reinforcement. However, suppose that under other conditions, reinforcement had been obtained consistently only after a list had been written and used, but not otherwise. Would the individual come to write lists under these conditions, despite the extra time and effort required? Practical experience suggests that individuals with mental retardation may have difficulty learning such discriminations. Just as with oral naming (Constantine & Sidman, 1975; Geren et al., 1997; Gutowski et al., 1995), potentially useful behavior (like list writing) that they have already learned may not become controlled by the cues that allow discrimination of the task demands (e.g., the presentation of two- vs. six-picture sample stimuli).

Overview

Ben's and Lori's performances during the preliminary assessment and Study 1 suggested that having a written list was not necessary for success on the two-picture matching trials. In contrast, success on six-picture trials was guaranteed only when a list was available at the time of matching. To verify

this experimentally, Study 2 began with a baseline phase that established control over not writing and writing by the dictated cues "don't write" and "write." This baseline also gave the participants an immediate history with the consequences for both not writing and writing in the presence of the two- and six-picture samples. Two subsequent phases followed: First, in sessions that included the baseline trials, we presented choice trials with two- and six-picture samples. In those trials, the participants could either write a list and keep it during the selection of picture comparisons or not write a list. In another phase, we presented only the choice trials; no baseline trials were given. During both of these phases, Ben and Lori were not expected to write lists on two-picture trials because doing so would not increase the likelihood of reinforcement but would actually delay reinforcer delivery. In contrast, both were expected to write lists on six-picture trials because doing so ensured reinforcement.

Ben's Procedure and Results

There were three phases to Ben's study. Phase 1 involved the development of a mixed baseline involving two- and six-picture trials. Choice responding was assessed in Phase 2 and the stimulus control of list writing by the picture samples was assessed in Phase 3. All trials involved a 0-s delay, and some aspects of the procedure differed from that used previously: (a) The slips of paper and a pencil were available at the beginning of all trials; (b) the trainer did not shield the computer screen (except as noted below); and (c) after a correct list was written (errors corrected as above), the participant touched the sample, which removed it from the screen and produced the comparison pictures.

Phase 1: Baseline with "write" and "don't write" trials. Phase 1 (Sessions 54 to 68) began with pretraining, using trials with one-picture samples. In Sessions 54 and 55 there were 24 trials, an initial 12-trial block accompanied by the dictated cue "write," followed by a 12-trial block with the cue "don't write." Ben's accuracy in these sessions was 92% and 100%. Ben was also perfect in Sessions 56 to 58, which involved unsystematic mixtures of 12 "don't write" and 12 "write" trials. Next, in Sessions 59 to 68, a baseline of two- and six-picture trials was established. Each of these sessions involved a mixture of 24 trials: There were 12 two-picture trials, six with the cue "don't write" and six with the cue "write." There were also 12 six-picture trials, six with the cue "don't write" and six with "write." Ben was not required to read the list on any of the trials.

Table 1 reflects Ben's performance on the last six sessions of Phase 1, which are representative of all 10 baseline sessions. The proportions in each row reflect the number of trials in which all six pictures selected were correct. Ben was perfect on two-picture trials with the list and without it. Ben was also perfect on six-picture trials with a list, but the number of correct trials varied without the list. For example, in Session 63, Ben selected all six pictures correctly on five of six such trials; in Session 68, all six pictures were matched on only one trial. On three trials in Session 68, Ben selected fewer than six pictures, but four or five of these selections matched the sample. On the two remaining trials, no picture matching occurred because Ben touched the DONE key immediately after touching the sample. In general, Ben's performance on the six-picture trials without a list during Phase 1 resembled his earlier performance (Figure 4) on the three kinds of trials involving differential responding and no list.

Ben took less time to write lists on trials with two-picture samples than on trials with six-picture samples. During the last six sessions, Ben took an average of 11.2 s to write two-item lists and 35.5 s to write six-item

Table 1
Results for Ben in Study 2: Correct Selection per Trial with Two- and Six-Picture Samples When a List Was and Was Not Written

	Two-picture samples		Six-picture samples	
Session	Not written	Written	Not written	Written
Phase 1: Baseline with "write" and "don't write" trials				
63	6/6	6/6	5/6	6/6
64	6/6	6/6	2/6	6/6
65	6/6	6/6	2/6	6/6
66	6/6	6/6	4/6	6/6
67	6/6	6/6	3/6	6/6
68	6/6	6/6	1/6	6/6
Phase 2: Tests with choice trials				
69	1/1	5/5	1/1	5/5
70	—	5/6	—	6/6
71	6/6	—	—	6/6
72	515	1/1	0/1	5/5
73	6/6	—	—	6/6
74	6/6	—	—	6/6
75	5/6	—	0/1	5/5
76	6/6	—	0/1	5/5
77	6/6	—	—	6/6
Phase 3: Tests with pictures only				
78	10/10	2/2	—	12/12
79	11/11	1/1	0/1	11/11
80	11/11	1/1	0/1	11/11
81	11/11	1/1	—	12/12

Note. Each proportion reflects the number of trials in which all six pictures matched the sample out of the total for that particular type of trial. The dashes indicate the absence of one or more choices of that trial type.

lists. Even when the lists were not written, the two-picture samples were on the computer screen for less time (2.3 s) than the six-picture samples (8.8 s).

Phase 2: Tests with choice trials. In Phase 2 (Sessions 69 to 77), sessions involved an unsystematic mixture of 24 trials. There were 12 two-picture trials, three accompanied by the dictated cue "don't write," three by "write," and six by "you choose" (the choice trials). Likewise, of the 12 six-picture trials, three were "don't write" trials, three were "write" trials, and six were "you choose" trials.

Table 1 shows performance on the six choice trials with two-picture samples and with six-picture samples. (Baseline data resembled Phase 1 and are not shown.) The proportions show the number of correct trials that occurred when a list was written and when it was not. In Session 69, Ben was correct on all five two-picture trials when he wrote a list and on the one trial when he did not. In Session 70, Ben chose to write a list on all six trials and was correct on five of them. In Sessions 71 to 77, matching occurred on nearly all two-picture trials even though Ben chose not to write a list. In Session 69, Ben also matched perfectly on the five six-picture trials when a list was written and on the one trial when he did not write a list. In five of eight remaining sessions, Ben wrote a list on all six trials and matched perfectly. In each of the three other sessions, Ben was perfect on the five trials when he wrote a list and incorrect on the one trial when he did not.

Phase 3: Tests with pictures only. In Phase 3 (Sessions 78 to 81), all dictated cues were removed from the sessions, which now involved a mixture of 12 two-picture and 12 six-picture trials. Table 1 shows that Ben almost always refrained from writing and matched correctly on the two-picture trials, but wrote a list and matched correctly on the six-picture trials.

Lori's Procedure and Results

The three phases used with Ben were repeated with Lori, along with additional baseline and training conditions. All trials involved a 0-s delay.

Phase 1: Baseline with "write" and "don't write" trials. In Phase 1 (Sessions 64 to 80), Lori accomplished the same pretraining as Ben in five sessions: She was always perfect except in the second session (96%). Next, as with Ben, a baseline of two- and six-picture trials was established in 12 sessions. Table 2 shows performance on the last six baseline sessions. Scores on all two-picture trials were high, whether a list was written or not. On six-picture trials, scores were high when a list

Table 2
Results for Lori in Study 2: Correct Selection per Trial with Two- and Six-Picture Samples When a List Was and Was Not Written

	Two-picture samples		Six-picture samples	
Session	Not written	Written	Not written	Written
Phase 1: Baseline with "write" and "don't write" trials				
75	6/6	6/6	0/6	5/6
76	5/6	6/6	0/6	4/6
77	6/6	6/6	0/6	5/6
78	6/6	5/6	0/6	6/6
79	6/6	6/6	0/6	5/6
80	6/6	6/6	0/6	5/6
Phase 2a: Tests with choice trials				
81	6/6	—	1/5	1/1
82	3/4	2/2	0/5	1/1
83	4/4	2/2	0/4	2/2
84	1/1	5/5	0/5	1/1
85	2/2	4/4	0/5	1/1
86	3/3	3/3	0/5	1/1
Phase 2b: Changed baseline and tests with choice trials				
87	4/4	2/2	0/6	—
88	5/5	1/1	0/5	1/1
89	5/5	1/1	0/6	—
90	4/4	2/2	0/6	—
91	4/4	2/2	0/6	—
92	5/5	1/1	0/6	—
Phase 3: Tests with pictures only				
93	12/12	—	0/12	—
94	—	11/12	0/2	7/10
95	—	12/12	0/1	12/12
(Sessions 96–137 involved Phase 4: Supplemental intervention)				
Phase 5: Tests with pictures only				
138	12/12	—	0/1	11/11
139	12/12	—	—	12/12
140	10/10	2/2	—	12/12
141	12/12	—	—	12/12
142	12/12	—	—	12/12
143	12/12	—	—	12/12

Note. Each proportion reflects the number of trials in which all six pictures matched the sample out of the total for that particular type of trial. The dashes indicate the absence of one or more choices of that trial type.

was written. In contrast, when a list was not written, scores were always zero. (The number of pictures matched correctly out of six on a trial ranged from two to five.) On average (mean), Lori took 13.5 s and 39.1 s to write two- and six-item lists, respectively. When a list was not written, the two-picture samples were on the screen for 2.3 s on average and the six-picture samples were on for 3.0 s.

Phase 2a: Tests with choice trials. Lori was given choice trials in Phase 2a (Sessions 81 to 86), which resembled Phase 2 for Ben. (Baseline data resembled Phase 1 and are not shown.) Table 2 shows that Lori's performance differed from Ben's: On two-picture trials, the choice to write a list (rather than not write) varied inconsistently and matching accuracy was always high. On six-picture trials, Lori usually did not write a list and then failed to match the sample. In contrast, on the occasional trials when Lori wrote a list, she matched successfully.

Phase 2b: Changed baseline and tests with choice trials. By manipulating the verbal cues presented on baseline trials (Sessions 87 to 92), we tried to discourage writing on two-picture trials and to encourage writing on six-picture trials. Sessions were the same as in Phases 1 and 2a except that (a) the verbal cue "don't write" accompanied all six baseline trials with two-picture samples, and (b) the verbal cue "write" accompanied all six baseline trials with six-picture samples. Lori's performance on baseline trials did not change (not shown in Table 2). On the majority of the choice trials with both two- and six-picture samples, Lori did not write a list. Matching on two-picture trials remained perfect, whereas errors occurred on almost all six-picture trials.

Phase 3: Tests with pictures only. Phase 3 (Sessions 93 to 95) was the same as Phase 3 with Ben. In the first of these sessions, Lori tended not to write on the two- or the six-picture trials, whereas in the second and third sessions, she wrote a list on almost all trials. Matching scores were as before: accurate on two-picture trials, regardless of whether a list was written, and accurate on six-picture trials only when a list was written.

Phase 4: Supplemental intervention. This

four-part intervention was designed to establish control by the two- and six-picture samples of not writing and writing a list, respectively. Part 1 (Sessions 96 to 113) involved 24 trials and resembled the changed baseline used in Phase 2b: There were 12 trials with two-picture samples and the cue "don't write" and 12 trials with six-picture samples and the cue "write." Only some of the possible combinations of 12 stimuli were used to create two- and six-picture sample displays for this training (other combinations of stimuli were kept for tests given in Part 4). After eight sessions, Lori refrained from writing on the two-picture trials, and accuracy was always 100%. However, on the six-picture trials Lori often touched the sample instead of writing when the dictated cue "write" was presented. To interrupt this pattern, the trainer used a cardboard shield on all trials to block responses to the sample until the writing materials were in place and the dictated cue had occurred twice. The shield was then removed to allow a response to the two- or six-picture sample that appeared. For the next 10 sessions, Lori wrote only on the six-picture trials, and accuracy on both two- and six-picture trials was high.

A form of oral self-instruction was added for Parts 2 to 4. This was done because procedures that establish supplemental verbal behavior have been found to increase the likelihood that instructional stimuli will come to exercise discriminative control of responding (e.g., Constantine & Sidman, 1975; Geren et al., 1997; Glat, Gould, Stoddard, & Sidman, 1994; Gutowski et al., 1995). First, we taught Lori to repeat the "don't write" and "write" cues that already controlled writing, and also to say aloud "don't write" and "write" in the presence of two-picture and six-picture samples, respectively. The purpose was to ensure that both the dictated cues and the picture samples controlled Lori's productions of "don't write" and "write" and, in turn, the occurrence of list writing.

The sessions in Part 2 (Sessions 114 to 122) involved 24 trials. The first block of eight trials involved a mixture of four trials with two-picture samples and the cue "don't write" and four trials with the six-picture samples and the cue "write." On these trials, Lori first was prompted to imitate the cue dictated by the computer. The shield was then removed and Lori was permitted to write or not write a list, touch the sample, and complete the trial. During the remaining 16 trials, the computerized dictated cue "What are you going to do?" was presented once before the trainer removed the shield to expose the sample and prompted Lori to say "don't write" when the sample was two pictures and to say "write" when the sample was six pictures. Lori then completed the trial as before. In the first session of Part 2, Lori was prompted to imitate (e.g., "Lori, say 'don't write'") the computer on each of the eight trials. On the ninth trial a two-picture sample accompanied the question "What are you going to do?" and Lori said "write." The trainer corrected Lori by saying "On this trial, you don't write," after which Lori said "Oh, don't write" and completed the trial. She continued to self-instruct correctly for the rest of the session. Subsequent sessions required no prompting. In the fourth such session, the cardboard shield was gradually removed (exposing more and more of the computer screen) and then was not used for five consecutive sessions. During these five sessions, Lori's writing and matching performances were nearly perfect. Part 3 (Sessions 123 to 130) was just like the final sessions of Part 2; the shield was not used, and all types of trials were mixed unsystematically. Finally, in Part 4 (Sessions 131 to 137) the procedure remained the same, but the samples involved combinations of the 12 pictures not used in Parts 1 to 3. Through-

out Parts 3 and 4, Lori's self-instruction, writing, and matching were almost errorless.

Phase 5: Tests with pictures only. Phase 5 (Sessions 138 to 143) repeated the conditions used in Phase 3: No dictated cues were given to prompt repetition of the names dictated by the computer or to say "don't write" and "write" to the sample stimuli. In contrast to performance during Phase 3, Lori's matching now was nearly perfect, and she almost always refrained from writing lists on two-picture trials but wrote lists on six-picture trials (Table 2). Lori rarely said anything during these trials but occasionally she whispered "don't write" and "write" appropriately to the two- and six-picture samples.

Discussion

During baseline trials, Ben and Lori learned to forego writing a list in the presence of the cue "don't write" and two- or six-picture samples. On other trials, they learned to write a two- or a six-word list in the presence of the dictated cue "write" and two- or six-picture samples. With or without a list, Ben and Lori matched two-picture samples almost perfectly, even though writing a two-item list delayed reinforcement. In contrast, both participants matched pictures relatively accurately on the six-picture trials when they wrote a list, which usually took over 30 s. On six-picture trials without a list, Ben's matching accuracy was variable and Lori was never correct.

Because the writing of two- and six-item lists was related differently to matching, we speculated that the participants' writing would occur differentially in the presence of the two- and six-picture samples. During the choice trials, the contingencies on two-picture trials favored not writing a list because writing did not increase the likelihood of reinforcement but instead lengthened the time to reinforcement over fourfold. In contrast, the contingencies on six-picture trials clearly favored writing a list, despite the amount of time it took to write a list. As expected, Ben almost immediately refrained from writing two-item lists and wrote six-item lists, thus receiving most of the available reinforcers in the minimum amount of time.

Initially, the allocation of Lori's list writing was not the same as Ben's. For Lori, the occurrence of list writing was apparently controlled by the dictated cues "don't write" and "write" rather than by the two- and six-picture samples. However, supplemental training established control by these sample stimuli (Phase 4). Tests with new samples (Part 4) then demonstrated the generality of that control. Success on tests with only the picture samples then followed (Phase 5). Although this intervention with Lori was not formally analyzed, its seeming success is consistent with prior studies that have used oral naming to establish stimulus control in delayed matching tasks (e.g., Constantine & Sidman, 1975; Geren et al., 1997; Gutowski et al., 1995). It is also interesting that Lori may have used the newly acquired verbal skills as a kind of self-instruction (sometimes whispering "don't write" and "write") during Phase 5. This reflected the contingencies to which she had been exposed in Phase 4, although the procedure during Phase 5 did not require such responses to the sample.

GENERAL DISCUSSION

Study 1 analyzed behavioral sequences that involved writing a list of the names of pictures displayed on a computer, reading the list, and then, after a delay, selecting the pictures from a larger set. Three participants with mental retardation were able to write and read lists of six picture names. However, errors occurred in the matching component of the task unless a written list was available when the comparison pictures were selected. The superiority of matching with a list suggests that the list functioned as a mediating stimulus that bridged the delay until the op-

portunity for matching occurred. Because differing contingencies resulted from writing lists of two and six names, Study 2 examined whether writing would occur in the presence of the two- and six-picture samples. Ben refrained from writing on test trials with two-picture samples but wrote and used a list on trials with six-picture samples. After supplemental training, Lori's writing was also differentially controlled by the two- and six-picture samples. Thus, Ben and Lori not only learned to write and use lists of instructional stimuli to mediate delays but also learned to discriminate the conditions under which writing a list helped (or was necessary) to satisfy the reinforcement contingencies efficiently. The results extend Stromer, Mackay, Howell, McVay, and Flusser's (1996) examination of mediation by written lists, suggesting the usefulness of further analyses of the computer-based methods. With respect to subject generality, Lori's results suggest that teaching functional mediation skills via writing may be a realistic goal even with some individuals whose academic and language skills are only poorly developed.

The repertoires acquired by the participants before this study were critical for the results. For example, the participants were already able to match the pictures and printed words to dictation and to one another, produce the appropriate written names to dictation and to pictures, and name the pictures and printed words orally when they entered the study. Apparently, sets of these stimuli were functionally related to one another as members of arbitrary stimulus classes, and these class memberships may be central to the mediated performances observed (Stromer, Mackay, Howell, McVay, & Flusser, 1996). The stimuli in each class were substitutable for one another. Thus, a list written in response to a set of pictures was also likely to function as a sample that later determined the selections among the pictures presented as comparisons during the matching component of the trials. Notably, this makes the task one that requires simultaneous arbitrary matching rather than delayed identity matching to the pictures. The basis for this possibility has been demonstrated in studies showing that the production of words in spelling may give rise to new performances that involve the matching of pictures and printed words (e.g., Mackay, 1985; Mackay & Sidman, 1984; Stromer & Mackay, 1992, 1993).

Study 2 complements a growing body of research that has applied the concepts and procedures derived from studies of choice (e.g., Mace, 1994; Pierce & Epling, 1995). Moreover, the differing results for Ben and Lori highlight the complexity of applied analyses of choice responding (e.g., Fuqua, 1984; Mace, Neef, Shade, & Mauro, 1994, 1996) and the importance of examining the stimulus control aspects of the present procedure. During baseline, four different complex instructional stimuli were derived from the dictated cues "don't write" and "write" and the two- and six-picture samples. These complex stimuli were related consistently to different behaviors and consequences. We expected the occurrence of writing on the choice trials to be influenced by (a) the more immediate delivery of reinforcement that followed not writing on two-picture trials and (b) the increased frequency of reinforcement that followed writing a list on six-picture trials. It was anticipated that writing would occur only in the presence of six-picture samples.

For Ben, the procedure quickly established appropriate stimulus control of writing by both the dictated cues and the samples. This apparently enabled the virtually immediate allocation of not writing and writing on trials with only the two- and six-picture samples, respectively. Note, however, that this outcome would not be expected if only the dictated cues "don't write" and

"write," and not the sample pictures, controlled whether a list was written. Prior to Lori's supplemental training (Phase 4), whether she wrote a list may have been under such exclusive control of the dictated cues, although these cues were consistently correlated with the presentation of the two- and six-picture samples. This possibility suggests a form of overshadowing (e.g., Kamin, 1968, 1969); the pictures were redundant stimuli that were functionally irrelevant to initiation of the written components of the tasks. Furthermore, the contingencies that were derived from the requirements of list writing were unlikely to generate attention to potential relations between the samples, writing, and trial outcomes. During the initial testing with the "you choose" trials, Lori usually did not write a list, whether the sample involved two or six pictures, which were on the screen about the same amount of time (2.3 s and 3.0 s, respectively). This may reflect (a) avoidance of an effortful response sequence that resulted in delayed reinforcement and (b) maintenance of responding without a list because even errors on six-picture trials were followed by presentation of an easier two-picture trial and virtually assured immediate reinforcement. This situation, which pits delayed reinforcement for an effortful response against more immediate reinforcement for an easier response, resembles the contingencies under which a kind of impulsive responding has been observed (e.g., Ainslie, 1974; Neef, Mace, & Shade, 1993; Rachlin & Green, 1972). But as Lori went on to show, such responding is amenable to intervention.

The supplemental intervention used with Lori succeeded in establishing the desired stimulus control of writing by the picture samples. This demonstration, however, merely emphasizes the need for analyses of such methods, because teaching someone to write and use lists as mediators in various tasks has important educational and clinical implications (see reviews by Stromer & Mackay, 1996; Stromer, Mackay, & Remington, 1996). Variants of the methods used here may establish mediating behaviors that are helpful in natural settings (Stromer, Mackay, Howell, McVay, & Flusser, 1996). Besides shopping, the feasible applications of lists of textual stimuli in work, residential, and therapeutic settings are plentiful and should be explored (e.g., Albin & Horner, 1988; Bourgeois, 1990; Cuvo, Davis, O'Reilly, Mooney, & Crowley, 1992; Lalli & Browder, 1993). Training that establishes written mediating behavior has the potential advantage that it may broaden an individual's relevant behavioral repertoire by adding the written form of names to existing stimulus classes that already include stimuli such as pictures and their oral names (e.g., Mackay, 1985; Mackay & Sidman, 1984; Stromer & Mackay, 1992, 1993; Stromer, Mackay, Howell, McVay, & Flusser, 1996). Furthermore, such behavior may have wide generality, because the stimulus control properties of the written material may be relatively "easily transported" from one learning situation to another (Kirby & Bickel, 1988, p. 123; and see Stokes & Baer, 1977, pp. 361–362).

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STUDY QUESTIONS

1. Describe the general experimental arrangement used in the study.

2. Describe the four types of trials conducted during Study 1 and briefly summarize the results obtained. Based on Lori's results, what additional type of trial should have been run?

3. What was the purpose of the second study?

4. How did the authors insure that participants were exposed to the "natural" contingencies associated with list writing?

5. Why did the authors expect participants, when given a choice, to write lists only in the presence of six-picture samples?

6. How did Lori's results differ from those obtained for Ben? What additional intervention was subsequently used with Lori?

7. The authors suggested that Lori's initial failure to write lists on choice trials reflected "impulsive" behavior. What is the basis for this speculation?

8. Based on the results obtained in this study, what appears to be the main benefit of teaching list-writing behavior?

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